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NUREG-0985
Rev. 2

U.S. Nuclear Regulatory Commission Human Factors Program Plan

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U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

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NUREG-0985
Rev. 2

U.S. Nuclear Regulatory Commission Human Factors Program Plan

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FOREWORD

The U.S. Nuclear Regulatory Commission's Policy and Planning Guidance for 1982 (NUREG-0885, Issue 1) called for development of a long range human factors program plan. An initial version of the Human Factors Program Plan was issued in July 1983. Revision 1 of NUREG-0985 was issued in September 1984 to reflect allocations of the estimated FY-1985 budget and to respond to the requirements of Section 306 of the Nuclear Waste Policy Act of 1982 (PL 97-425). Revision 2 of the plan incorporates recent Commission decisions and policy related to elements of the plan. With a few exceptions, the principal effect of Revision 2 is to shift the plan from staff development efforts to staff evaluation of industry self-initiatives and the effectiveness of industry self-improvement.

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NOMENCLATURE

AEOD	Office of Analysis and Evaluation of Operational Data
AI	artificial intelligence
ANS	American Nuclear Society
ANSI	American National Standards Institute
AOA/ES	Advanced Operator Aids/Expert System (EPRI Program)
AOP	abnormal operating procedure
BWR	boiling water reactor
CFR	Code of Federal Regulations
CRGR	Committee to Review Generic Requirements
CRT	cathode ray tube
DHFT	Division of Human Factors Technology
DOE	Department of Energy
DSRO	Division of Safety Review and Oversight
EDO	Executive Director for Operations
EEI	Edison Electric Institute
EOP	emergency operating procedure
EPRI	Electric Power Research Institute
FY	fiscal year
GL	generic letter
HFPP	Human Factors Program Plan
HRA	human risk analysis
IE	Office of Inspection and Enforcement
IEEE	Institute of Electrical and Electronic Engineers
INPO	Institute for Nuclear Power Operations
LER	licensee event report
M&O	management and organization
MMI	man-machine interface
MOA	Memoranda of Agreement
NAS	National Academy of Sciences
NPP	nuclear power plant
NRC	U.S. Nuclear Regulatory Commission
NRR	Office of Nuclear Reactor Regulation
NSSS	nuclear steam supply system
NTOL	near-term operating license
NUMARC	Nuclear Utility Management Resources Committee
OP	operating procedure
PAT	performance appraisal team
PRA	probabilistic risk assessment
PWR	pressurized water reactor
QA	quality assurance
RES	Office of Nuclear Regulatory Research
RG	regulatory guide
RO	reactor operator
SALP	systematic appraisal of licensee performance
SPDS	Safety Parameters Display System
SRO	senior reactor operator
SRP	Standard Review Plan
TMI-2	Three Mile Island Unit 2

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1 INTRODUCTION

1.1 Purpose

The purpose of the U.S. Nuclear Regulatory Commission (NRC) Human Factors Program Plan (NUREG-0985, Revision 2) is to ensure that proper consideration is given to human factors in the design and operation of nuclear facilities. This revised plan addresses human factors issues related to the operation of nuclear power plants (NPPs). The three issues of concern are (1) the activities planned to provide the technical bases to resolve the remaining tasks related to human factors as described in NUREG-0660, "The NRC Action Plan Developed as a Result of the TMI-2 Accident," and NUREG-0737, "Clarification of TMI Action Plan Requirements"; (2) the need to address the additional human factors efforts that were identified during implementation of the Action Plan; and (3) the actual fulfillment of those developmental activities specified in Revision 1 of this plan. The plan represents a systematic approach for addressing high priority human factors concerns important to NPP safety in FY 1986 through 1987.

1.2 Background

The functions, capabilities, and limitations of the personnel involved in the operation of NPPs must be thoroughly understood and considered in the effort to evaluate the safety of NPPs. The accident at Three Mile Island Unit 2 (TMI-2) alerted us to the need to examine the involvement of human factors in NPP regulation and operation more thoroughly than had been done up to that time. NUREG-0660 was issued to describe a number of tasks that needed to be performed by the nuclear industry and the NRC. A significant number of these tasks were aimed at improving NPP safety through increased attention to the human element. To illuminate this concern, an analysis was performed of licensee event reports (LERs). That analysis indicated that about one third of all reportable events directly involve human performance.

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In June and December 1980, the Commission issued policy statements that expanded and clarified the Commission's regulation of human factors safety issues beyond the requirements in NUREG-0737. The licensing review process now stresses consideration of human factors areas such as:

(1) NPP staffing to ensure that the numbers, functions, and qualifications of personnel are adequate for safe operation;

(2) training programs for both licensed and nonlicensed NPP staff to ensure that personnel are able to meet existing job performance requirements;

(3) licensing examinations to ensure validity, reliability, and fairness of examinations and the examination process;

(4) procedures to ensure their adequacy and effectiveness;

(5) NPP control rooms and remote shutdown panels to ensure that they are designed to facilitate reliable human actions at the man-machine interfaces (MMI);

(6) utility management and organization to ensure its adequacy to support safe NPP operation; and

(7) the impact of human error and human performance on NPP operation to ensure the development of adequate human factors information to support NPP safety.

In 1982 the Commission approved SECY 82-111, "Requirements for Emergency Response Capability." These requirements were published as Supplement 1 to NUREG-0737 and transmitted to the industry as Generic Letter 82-33. This action applied important human factors requirements to operating plants, primarily in the areas of MMI and upgraded procedures, including training related to these two areas. The schedule for accomplishing these activities has been established through negotiation between Office of Nuclear Reactor Regulation (NRR) project managers and the utilities.

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Section 306 of the Nuclear Waste Policy Act of 1982 (PL 97-425) directed the NRC to promulgate regulations or other appropriate guidance for the training and qualifications of civilian nuclear power plant operators, supervisors, technicians, and other appropriate operating personnel. In addition, PL 97-425 required NRC to establish simulator training requirements for applicants for operator licenses and for operator requalification programs, requirements governing NRC administration of requalification examinations, requirements for operating tests at civilian nuclear power plant simulators, and instructional requirements for licensee personnel training programs. Section 306 required significant revisions in the activities and schedules of many Human Factors Program Plan efforts. Revision 1 to this plan reflected these changes, and Sections 3.1 and 3.2 of this revision address further efforts in this area.

1.3 Structure of the Program Plan

The Human Factors Program Plan is structured as follows:

Section 1 describes the background that led to this plan, current activities, and program management;

Section 2 describes the special issues that either affect all aspects of the program or require involvement of more than one program element for their resolution; and

Section 3 addresses the seven major program elements and the major tasks to be performed in FY 1985 through 1987. Any industry activities that are related to a particular program element also are addressed, as appropriate. The seven major program elements are:

(1) Training
(2) Licensing Examinations
(3) Procedures
(4) Man-Machine Interfaces
(5) Staffing and Qualifications
(6) Management and Organization
(7) Human Performance

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Appendix A describes accomplishments to date in implementing the earlier versions of this plan. Appendix B tabulates the status of the human factors elements of the TMI Action Plan. Appendix C tabulates major milestones in this update of the Human Factors Program Plan.

1.4 Current Activities

The activities planned within these program elements will provide the technical bases for developing regulatory guidance, if necessary, or for concluding that nuclear industry self-improvement activities are effective and will suffice to assure the capability of nuclear plant staffs to effectively perform activities important to safety. In addition, the elements of the plan are designed to equip the NRC staff with the bases needed for the licensing function in human factors areas. Activities implemented under earlier revisions of the program plan supported decisions regarding the approach to regulatory action to resolve human factors issues. If the results of the programs indicate that new requirements should be promulgated, such proposals will undergo the normal review process, including development of a regulatory analysis, review by the Committee to Review Generic Requirements (CRGR), and evaluation, where appropriate, under the Backfit Rule.

This revision of the plan incorporates recent Commission decisions and policy related to elements of the plan and reflects FY-1986 budget constraints, which resulted in deferral or cancellation of a number of previously planned activities.

The Commission's decision not to proceed with general operating criteria and to defer rulemaking on training was based, in part, on the Commission's decision to encourage industry initiatives and self-improvement to the extent that such industry activities are effective and consistent with regulatory responsibilities. As a result of these decisions, the NRC staff's role has shifted from regulatory development efforts to evaluation of industry initiatives and self-improvement programs. Recent decisions related to reducing the FY-1986 Federal deficit have reduced the NRC's proposed FY-1986

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budget. These budget cuts have resulted in significant reductions in the following planned Human Factors Program Plan activities:

- All human factors activities not related to probabilistic risk assessments (PRAs) by NRC's Office of Nuclear Regulatory Research (RES) were cut;

- All medium and low priority activities have either been cancelled or deferred by NRR; and

- Responsibility for management of NRC activities related to the Halden Project were transferred from RES to NRR.

Efforts by the government to further reduce the federal budget deficit, e.g., the Gramm-Rudman-Hollings bill, may result in further budget cuts. Since the magnitude and allocation of such cuts are unknown today, they have not been anticipated in the plan. These reductions may necessitate deferral or cancellation of other planned accomplishments listed in this plan.

1.5 Program Management, Coordination, and Integration

The success of this plan relies on effective interactions within the NRC and between the NRC and industry. The systems approach taken in this plan is intended to provide assurance that NRC human factors activities are appropriately integrated and that adequate and accurate human factors information is developed. The plan recognizes that activities initiated within INPO, IEEE, EPRI, Edison Electric Institute (EEI), utility Owners Groups, and individual utilities often provide essential information to complement the activities described herein. To ensure that available information is effectively and efficiently used, these activities, and those at other Federal agencies and in foreign countries, will be coordinated and integrated with those described in this plan. Memoranda of Agreement (MOA) with INPO have been signed for those INPO activities related to staff efforts. Activities by the Nuclear Utility Management Resources Committee have been incorporated in this plan as appropriate.

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The Director, NRR has overall responsibility for implementation of the NRC Human Factors Program Plan (HFPP). The following program management controls will be implemented to ensure effective management, coordination, and integration:

- The Director, Division of Human Factors Technology (DHFT) is delegated responsibility for overall management, coordination, and integration;

- A cognizant Branch Chief will be assigned responsibility for management, and implementation of each program element;

- Quarterly program element reviews will be held by the Director, DHFT for each program element;

- Semiannually the overall program progress will be reported to senior NRC management (e.g., Directors, NRR, EDO, and other involved Office Directors); and

- Annually the staff will report to the Commission program status and progress toward resolution.

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2 SPECIAL ISSUES

Some special issues that impact the Human Factors Program Plan are relevant to more than one program element. These issues of concern are discussed below.

2.1 Prioritization

The staff recognizes that there must be orders of priority among the plan elements and among activities of individual elements. The plan was prioritized by the Division of Safety Technology (DST) in accordance with procedures established in NRR Office Letter 40. As a result of the FY-1986 and -1987 budget constraints some activities which were previously prioritized as low or medium priority have been deleted or deferred. In general, activities and end products associated with evaluation of industry self-initiatives and the effectiveness of industry self-improvement and near-term regulatory actions will be given priority over activities related to review of advanced technologies. These latter activities are, however, considered high priority because they provide the necessary staff expertise to review, when proposed, the use of advanced technologies (e.g., new control room designs, artificial intelligence and computerized operator aids). The staff will undertake further efforts to sharpen the focus of the program upon the most important issues, and to develop a priority ranking of the outstanding issues.

2.2 Hardware vs. Training/Procedures Solutions to Problems

Frequently, solutions to design-related problems in NPPs are based upon people-oriented changes (e.g., modifications to training or procedures) without correction of the underlying design problem. While an appropriate resolution of some issues, continued reliance on this approach can overload operators and increase training programs. The attention operators pay to individual technical issues can also be diluted and may result in no increase

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in safety. Any decision to adopt people-oriented changes as the sole solution to a safety issue, instead of corrections to the basic design problem, must take into consideration the human factors aspect. Expanded training, possible increases in crew size, or in number of shifts, or in new procedures developed, and the probability of the operator's taking the required actions must be considered in the safety analysis. Recent incidents have confirmed the need to take such a systematic approach to the resolution of such problems and not necessarily rely on people-oriented changes as the sole solution to safety issues.

The hardware fix vs. procedural fix issue will arise many times as the NRC proceeds to resolve a number of Unresolved Safety Issues (USIs) and generic safety issues. One of the most important of these is the implementation of the Commission's policy statement on severe accidents. The staff has been working with the Industry Degraded Core Rulemaking group, IDCOR, to develop a resolution of severe accident issues for operating plants. Both IDCOR results and the NRC's Severe Accident Research Program are suggesting that accident management by plant operating staffs can go a long way to resolving concerns with severe accident risks.

The aggregate effect of the resolution of the several USIs generic safety issues, and severe accident issues may have important implications for the makeup, qualification, and training of operating shifts as well as for operator licensing, emergency operating procedures, simulator capabilities, the man-machine interface, etc.

The Division of Human Factors Technology will review proposed resolutions of severe accident issues, USIs, and generic safety issues to assure that: (1) the credit accorded operator action is acceptable, (2) the regulatory analysis adequately takes into consideration additional burdens, if any, placed upon operators, and (3) the regulatory program for human factors safety (e.g., operator licensing, training, procedures, etc.) appropriately reflects the additional burdens placed on reactor operations personnel.

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This concurrence review of draft rules and regulations is a responsibility of the Division of Human Factors Technology outside of the Human Factors Program Plan. However, from time to time it may be necessary to amend the Human Factors Program Plan to reflect necessary midcourse corrections to the human factors regulatory program.

2.3 Maintenance

The Commission's 1984 Policy and Planning Guidance (NUREG-0885, Issue 3) recommended the staff develop alternative regulatory approaches with respect to nuclear power plant maintenance. In response, the staff has developed the Maintenance and Surveillance Program Plan (SECY-85-129). During FY 1984, the staff considered including the Maintenance and Surveillance Program as an element in the HFPP. However, the definition and scope of activities involved in the Maintenance and Surveillance Program Plan are broader than those of the HFPP; therefore, implementation of the Maintenance and Surveillance Program Plan will be independent of the HFPP. The staff is coordinating their efforts on these plans to avoid duplication and to ensure that maximum results are obtained from both.

2.4 Probabilistic Risk Assessment

The ongoing and planned research has identified deficiencies and the lack of adequate NPP human error data for use in performing PRAs. Methods and techniques to substantially improve collection of NPP human error data for use in PRAs are being developed and evaluated. Additional research is underway in RES to improve the scope and thoroughness of human reliability analysis for use in PRA. The Human Reliability element activities related to human error probability from Revision 1 of the HFPP have been incorporated into the RES Reliability and Risk Analysis Methods Program Plan (NUREG-1093). Results from this program are expected in early FY 1987 and will be evaluated for relevant information on human performance, which will be fed back to the applicable HFPP elements.

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2.5 Advanced Technologies

The ongoing development and installation of a safety parameter display system (SPDS) is envisioned as an important step in upgrading existing NPP designs in plant control rooms. This was required by Supplement 1 of NUREG-0737. Most of the SPDS designs are based on computer technology and cathode ray tube (CRT) display techniques. It is anticipated that these expanded data and information management capabilities will be applied to other plant processes and procedures to make use of advanced technologies. As these new control and display technologies are being developed, guidance pertinent to the interface between them and the operator will be developed. The development of computer applications and artificial intelligence (AI) capabilities will effect process control and operating procedures.

2.6 Automation and Artificial Intelligence

The level of automation possible within the nuclear industry spans a range of possibilities from the fully manual, with locally operated valves, to the fully automated, employing artificial intelligence. The nuclear industry is basically at the one-switch one-valve end of that range. The reliability of artificial intelligence (AI) for safety-related uses is currently unproven; however, evidence from other industries suggests that there can be significant savings in operating costs as well as an enhancement in safety associated with increased automation of operator actions. Reducing the menial level workload of operators could provide better low-level control and fewer operator errors. Such automation can also free operators to concentrate on the cognitive level of operations. The subject of automation and AI affects control room design, operating procedures, and other operator aids, staffing, and training. The staff is investigating the benefits and hazards of increased automation in the nuclear industry and will consider incentives to encourage the industry to move toward automation as a means to increase plant safety.

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2.7 Nuclear Industry Initiatives

The Nuclear Utility Management and Resources Committee (NUMARC) was established by the utility industry in March 1984 with an objective of reviewing management and people-related issues in nuclear operations, and developing industry-wide resolutions. The staff will monitor the effectiveness of industry initiatives undertaken through NUMARC and report its evaluation to the Commission. NUMARC activities are identified in this plan for staff monitoring and evaluation; especially NUMARC's activities for the program elements of Staffing and Qualifications, Training, and Management and Organization. Industry initiatives in maintenance are being monitored as part of the Maintenance and Surveillance Program Plan.

2.8 National Academy of Sciences

The NRC has contracted with the National Academy of Sciences (NAS) to conduct an independent study of human factors research needs in the safe operation of nuclear power plants. This study, which will be completed in FY 1986, will include an assessment of relevant completed human factors research by NRC and industry and recommendations for future human factors research based on identified deficiencies and need.

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3 PROGRAM ELEMENTS

3.1 Training (Maintenance and Training Branch)

The goal of this element is to provide the means to ensure that NPP personnel are able to meet job performance requirements and that a mechanism exists to assess and, where necessary, improve the quality and effectiveness of training programs.

The Nuclear Waste Policy Act of 1982 (PL 97-425), Section 306, directed the NRC to promulgate regulations or guidance for the training of NPP personnel. Initially, a rule (10 CFR 50.200-50.250) and regulatory guide were proposed (SECY-84-76, 76A, 76B) to respond to that mandate. However, in recognition of the industry's initiatives in the area of training and in an effort to encourage further self-improvement, the Commission decided to refrain from new rulemaking in the training area for a period of at least 2 years. In doing so, the Commission directed the staff to develop a policy statement which endorses the INPO-managed Accreditation Program as the means of assuring that industry programs encompass the five essential elements of training presented in the policy statement.

It is the continuing responsibility of the NRC to evaluate applicants' and licensees' implementation of improvement programs to ensure that results are achieved and to evaluate the possible need for further NRC action based on the effectiveness of industry programs after the 2-year period.

Accomplishing this plan element will determine whether additional regulatory action is needed in training at the end of the 2-year period.

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3.1.1 Major Tasks

In response to PL 97-425 Section 306, NRC has developed policy guidance, a Memorandum of Agreement with INPO regarding training and qualifications, and training review procedures. In addition, NUREG/CR-4258, "An Approach to Team Skills Training of Nuclear Power Plant Control Room Crews," and NUREG/CR-4344, "Instructional Skills Evaluation in Nuclear Industry Training," have been published.

The staff has developed a review procedure to evaluate the industry's development and implementation of performance-based training programs. The procedure is designed to determine if the five essential elements of performance-based training are present in the programs being reviewed. In connection with the effort to monitor training, the Office of Inspection and Enforcement (IE) is implementing new performance-based training inspection modules. In addition, an observation protocol has been developed and is being used by the staff to assure consistency when observing INPO Accreditation Team visits.

These procedures and data gathered from other sources (e.g., SALP, examination reports) will enable the staff to evaluate the effectiveness of the INPO-managed Accreditation Program in ensuring that industry training programs produce the desired results.

Additionally, the staff will revise Section 13.2 of the Standard Review Plan (SRP) to use in evaluating training programs of applicants for operating licensees.

3.1.2 Industry Activities

The INPO-managed Accreditation Program is a major undertaking to ensure the adequacy of utility training programs. This effort has resulted in the establishment of a training accreditation process designed to upgrade the quality of utility training programs. INPO also has developed technical reports to provide guidelines and criteria for training and qualifications of both licensed and nonlicensed NPP personnel. INPO's job-task analysis identified areas of knowledge and skills to be used as the foundation for the

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development of curricula for training programs for licensed and selected nonlicensed personnel. INPO also has prepared a Training Systems Development manual for industry trainers to use in developing performance-based training programs.

3.2 Licensing Examinations (Operator Licensing Branch)

The primary goal of this element is to ensure that NRC-administered examinations consistently and validly measure the ability of reactor operator (RO) and senior reactor operator (SRO) candidates to perform their respective licensed duties and responsibilities safely.

The benefits that will result from the successful accomplishment of this goal include the validation of test content to ensure that the knowledge and abilities measured in licensing examinations are job-related and important. The standardization of examination procedures will increase the reliability and consistency in examination practices among individual examiners and across regions. Delineation of the licensed operator knowledge and abilities based on job-task analyses will result in more effective use of utility training materials to prepare licensing examinations, as well as providing those responsible for the training of licensed candidates with a better understanding of the bases, objectives, and criteria used in the NRC examinations.

The concerns associated with this effort are: (1) the implementation of changes resulting from these developmental efforts should not unduly burden examiners, license candidates, or utility training programs, and (2) inconsistencies may arise between knowledge and abilities derived for licensing examination purposes and those derived from plant-specific job-task analyses because the knowledge and ability catalogs will delineate the generic test content domain.

3.2.1 Major Tasks

Validated catalogs of RO/SRO knowledge and abilities are being developed for licensed operators, based on the INPO job-task analyses. Each draft catalog resulting from this process will be reviewed and tested by NRC licensing

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personnel. The need to further tailor the generic catalogs for the purpose of creating individual, plant-specific catalogs of knowledge and abilities for licensed operators also will be evaluated.

Work in the delineation of test content domains will focus on the existence of differences between the test content domains for initial and requalification examinations. If significant differences are identified, the RO/SRO catalogs will be reviewed to identify those areas of knowledge and abilities most appropriate for measuring operator competence in these two examinations.

A system will be developed to ensure that all knowledge and abilities catalogs stay current. The catalogs will be compared against other lists of generic knowledge, skills and abilities, when available, to ensure that catalogs contain complete and accurate information.

The procedural handbook for developing operator licensing examinations, using the knowledges and abilities catalogs, will be pilot-tested and revised. Further, a review of the existing catalog statements will be performed to determine if the knowledges and abilities should be supplemented with additional information related to the level of knowledge, extent of knowledge, and the most appropriate mode of testing of each statement.

Special attention will be given to the operating test portion of the examination. Procedures will be developed for use in constructing simulator scenarios, administering simulator examinations, scoring candidate performance, and reporting examination test scores. In addition, methods and criteria for evaluating the adequacy of NPP simulators for use in conducting operating examinations will be developed and validated. The qualifications required of personnel who perform these evaluations will be identified.

Examiner training programs will be implemented for examination changes adopted. Training program topics will involve the use of the handbook for developing operator licensing examinations, focusing on test outline development, test item construction, and candidate evaluation. Training will

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be conducted in the use of simulators for conducting operating examinations, focusing on simulator characteristics, observation skills, and systematic scoring and reporting procedures.

Existing regulations and regulatory guides (RGs) are being amended to reflect changes made in the examination process and to respond to PL 97-425. Revisions to 10 CFR 55 will ensure that these regulations reflect the systematic approach to the development of test material, as described above, including assurance that operating tests focus on the evaluation of candidates' ability to perform the actions necessary for the safe and competent operation of the facility. Revisions to RG 1.149, "Nuclear Power Plant Simulator for Use in Operator License Examinations," provide standards to judge the capabilities of simulation facilities for use in operator licensing. RG 1.8, "Qualification and Training of Personnel for Nuclear Power Plants," is being revised to endorse, with certain exceptions, ANSI/ANS Std. 3.1-1981, as well as to provide better consistency with recent utility efforts towards performance-based training. Revisions to RG 1.134, "Medical Evaluation of Nuclear Facility Personnel Requiring Operator Licenses," provide guidance in meeting the medical requirements proposed in 10 CFR 55 and endorse ANSI/ANS Std. 3.4-1983.

3.2.2 Industry Activities

INPO's control room operator job/task analysis is a major input in the development of content-valid examinations and will provide a basis for attempting to establish candidate evaluation criteria. Utility-derived test questions will be entered into the computerized Examination Question Bank and will serve as a source of examination material. Improved systems of updating examination reference material will be developed on the basis of facility changes. Subject matter experts from utility operating staffs will continue to assist in the development of knowledg and ability catalogs and other examination reference material. NUMARC has established a working group to study the issue of operator requalification, in cooperation with the NRC staff, identify potential problems, and recommend possible solutions. If problems are identified in operator requalification, the check operator concept will be reviewed as one of the possible solutions to those problems.

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3.3 Procedures (Human Factors Issues Branch)

The goals of this element are (1) to ensure the adequacy and effectiveness of procedures to operate nuclear power plants safely, (2) to assess the effectiveness of automatic versus manual control of actions that are necessary for establishing safety-related functions during emergency conditions, and (3) to evaluate the application of advanced technology (i.e., artificial intelligence) in the enhancement of NPP personnel performance.

The benefits from completion of this element will be (1) to enable the staff to better discriminate whether or not licensee's procedures are sufficiently effective to assure public health and safety under all plant conditions (including upset and degraded core conditions) and support the promulgation of new requirements should they be warranted, (2) to create a framework for evaluating the appropriateness of "reliance on the operator for safety-related actions" as a proposed resolution to unresolved safety and generic safety issues, and (3) to enable the staff to perform efficient safety evaluations for cases in which licensees propose the use of advanced technology as operator aids.

3.3.1 Major Tasks

Each nuclear plant owner is expected to develop function-oriented emergency operating procedures according to an NRC-reviewed and approved procedure generation package. Audits of a few plants to assess the function-oriented procedures have revealed deficiencies. The NRC is taking the following action to further assess and rectify the problem: (1) an IE Notice is being prepared to alert the industry to the deficiencies found thus far and to NRC follow-up plans, (2) an inspection module, in the form of a one-time Temporary Instruction, is being developed to guide an abbreviated audit of all licensees' emergency operating procedures, and (3) more intensive audits will be continued at a selected set of plants. NRR will draw upon the results of these audits to measure the scope and severity of problems in the licensees' implementation of their procedure generation package, and to determine whether further regulatory action is warranted.

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Under the severe stress of an accident, there is an increased likelihood that operators will make mistakes. A scoping study will be undertaken to estimate whether degraded operator performance under the stress of accidents is of a scale to warrant regulatory action and, if so, to determine whether the best approach lies in one or more of the following: (a) development of procedure guidelines, (b) alterations to the man-machine interface, or (c) special training to reduce the deleterious effects of accident stress on operator performance.

As indicated in Supplement 1 to NUREG-0737, "Requirements for Emergency Response Capability," upgraded EOPs will reduce risk during emergencies because "human-factored, function-oriented emergency operating procedures will improve human reliability . . . ." To test this assumption, studies are being conducted using survey and experimental techniques to evaluate the in plant effectiveness and impact of upgraded EOPs. A value/impact analysis will be performed as a part of this study to compare earlier event-based procedures with upgraded, function-based procedures. This analysis will aid in quantifying the results of the study in terms of (1) the effectiveness of event-based procedures versus the upgraded, function-oriented EOPs, (2) plant and environmental safety, and (3) cost to the industry and government. The results of this study will be used to identify needs for improvement to the NRC program for upgrading EOPs to further improve their effectiveness. Also, the methodology used to conduct this study may be applied to other investigations that evaluate the impact of other upgraded procedures on personnel performance and safety.

On the basis of current efforts to evaluate the quality of and the problems associated with existing plant procedures, NRR is evaluating the need to develop technical guidance for the industry to use to upgrade normal operating procedures (OPs) and abnormal operating procedures (AOPs) as the staff has done for emergency operating procedures. Future work in this area includes performing a regulatory analysis to determine whether regulatory action for other plant procedures is warranted, and, if so, to develop formal regulatory requirements.

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Preliminary investigation suggests that operators often experience difficulty when they are required to go from one procedure to another procedure. Studies based on operating experience and expert judgment are being used to develop guidance for recommending the appropriate interfaces that should occur within and between procedures. In addition, these efforts will determine the need for standardizing the different classes of procedures (e.g., normal, abnormal, emergency).

3.3.2 Industry Activities

The industry has several ongoing and planned research activities related to procedures enhancement. EPRI's program, Advanced Operator Aids/Expert System (AOA/ES), combines the Safety Parameter Display System (SPDS) with computer-based monitoring, enabling the operator to determine which emergency procedures to use in mitigating the consequences of an accident. The Halden project (a joint NRC/industry effort with other countries) plans to conduct a study on the computerization of procedures. INPO has developed procedure writing guidance for EOPs, Alarm Response Procedures, and Maintenance Procedures.

3.4 Man-Machine Interface (The Human Factors Issues Branch)

The goal of the activities in the area of man-machine interface (MMI) is to ensure the adequacy of the MMI in all aspects of nuclear power plant (NPP) operations to the extent necessary to assure that nuclear power plants pose no undue risk to public health and safety.

The concerns underlying this element are: (1) there are indications that the man-machine interface deficiencies of many local control stations at NPPs may make human error unduly likely, (2) the large number of annunciations and alarms that accompany serious upsets in NPP operation may confuse operators, and inhibit effective response, and (3) the staff is not yet prepared to conduct quick, efficient safety evaluations of licensee proposals to make innovative use of computerized displays, automation, or artificial intelligence in NPP controls. The benefits of completing this element are the resolution of these three concerns.

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The staff will encourage improved technology by minimizing regulatory burdens for licensees or applicants adopting improved MMI designs.

3.4.1 Major Tasks

To date, regulatory attention has been primarily limited to the man-machine interface in the control room and at the remote shutdown panel. Further evaluation is needed regarding interfaces at local control stations other than the remote shutdown panel. Operators use local control stations when control is not or cannot be effected from the control room. These local control stations are used routinely as well as on an emergency basis. The potential for human errors of both commission and omission in the manipulation of controls at local control stations can be reduced through the application of human factors engineering techniques similar to those applied in control room design reviews. The staff will evaluate the extent and safety significance of MMI problems at local control stations and propose alternative solutions for the problems identified. The staff will perform a regulatory analysis of any proposed solution and develop a regulatory position, if warranted, in accordance with the Backfit Rule.

NUREG-0700, "Guidelines for Control Room Design Reviews," provides a "standard of quality" for annunciator systems that, if incorporated, should minimize the potential for human error associated with these systems. Guidelines for annunciator system evaluation and near-term improvements have been developed by EPRI and the NRC. One of the major findings of these efforts was that during plant upsets the operators become "overloaded" with too many annunciators, reducing the system effectiveness and sometimes creating a negative factor. Advanced computer-based technologies are now available to provide the necessary logic to improve NPP annunciator systems.

Recommendations for advanced annunciator systems have been developed based on an evaluation of results of studies by EPRI, NRC, and the Halden project, and other advanced alarm system development activities at the Seabrook NPP and the Department of Energy (DOE) Savannah River Laboratory. Some utilities have initiated advanced alarm system studies. Some utilities also have expressed interest in upgrading their annunciator systems because the

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existing systems are performing poorly and procurement of spare parts is becoming difficult. The overall effectiveness of operational aid systems in improving operator performance and the relative effectiveness of techniques to avoid excessive numbers of alarms is being evaluated and, if appropriate, demonstrated through simulator or field testing. Based on the results of this evaluation, a regulatory analysis will be performed for alternative solutions and a regulatory position developed. Applicable regulatory guidance, review and evaluation criteria will then be developed. The regulatory position is expected to address those advanced annunciator system design issues relevant both to upgrades of existing systems and to next-generation control rooms.

The application of artificial intelligence (AI) to nuclear reactor operations, specifically in the area of personnel performance enhancement, is being monitored for possible future application. The objective of this effort is to maintain the ability to review AI applications that may be proposed to support nuclear power plant operations. Regulatory issues associated with AI include identifying which nuclear AI applications warrant regulatory oversight, determining how to evaluate the safety impact of the technology, and establishing the review criteria for acceptable applications. Applications being considered by the industry include AI products (known as "expert systems") that act as "consultants" to control room operators, automated (computerized) procedures for specific plant conditions, and machine handling of alarms based on operator-provided guidance.

It is anticipated that new control room designs will make extensive use of computers and computer-driven displays. The DHFT staff will monitor advanced control room design activities in the development of new plants and will monitor the incorporation of advanced control room concepts in modifications to existing operational plants. The staff will identify changes in workload of control room operators as a result of automation and identify performance requirements for functions allocated to computer-driven devices. The DHFT staff will review function/task allocation between humans and computers during abnormal and emergency condition of plant operations.

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The staff will evaluate industry guidelines on human interface hardware for computer-driven displays, which minimizes human error in the location, retrieval, access, and use of computer stored data, and identify the human factors features and faults of interactive computer graphic display devices. The staff also will evaluate the methods proposed by industry to validate and display plant data, considering both computer-processed data and analog hard-wired instruments.

3.4.2 Industry Activities

EPRI has several efforts underway directly relevant to the MMI program element. These efforts include the development of (1) a human factors primer tailored to the needs of the nuclear industry, (2) a procedure for reviewing and improving power plant communications, (3) guidelines for reviewing and improving power plant alarms, and (4) a computer-generated display system guide. The nuclear steam supply system (NSSS) vendors and the Halden project are engaged in the development and evaluation of advanced control room designs and alarm handling methods. Sub-Committee 7 (Human Factors) of the IEEE Nuclear Power Engineering Committee is developing a guideline entitled "Criteria for the Application of Human Engineering to Systems Equipment and Facilities of Nuclear Power Generating Stations."

3.5 Staffing and Qualifications (Human Factors Issues Branch)

The goal of this element is to provide a means to ensure that qualifications and staffing at nuclear power plants (NPPs) are adequate for safe operation. Section 306 of the Nuclear Waste Policy Act of 1982 (PL 97-425) directed the NRC to promulgate regulations or other regulatory guidance for the training and qualifications of appropriate plant operating personnel. Although the staff proposed rulemaking (SECY 84-76, 84-76A, and 84-76B), the Commission directed the staff to develop a policy statement on training and qualifications in response to the Act. The resulting "Commission Policy Statement on Training and Qualifications of Nuclear Power Plant Personnel" was published on March 20, 1985 (50 FR11147). This policy assigns the responsibility to industry for developing programs that will ensure that the personnel in categories covered by the INPO-managed Accreditation Program have appropriate qualifications.

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The issues of concern in this element include: (1) development of a technical basis for minimum experience and educational qualifications of NPP personnel, (2) the difficulties inherent in monitoring and objectively evaluating industry-based qualification programs, and (3) development of a technical basis for regulatory guidance for staffing and work scheduling for NPP personnel.

3.5.1 Major Tasks

The DHFT staff is in the process of developing guidance on the appropriate minimum qualification requirements of NPP personnel.

The final policy statement on engineering expertise on shift was approved by the Commission on October 28, 1985 (50 FR43621). At the behest of the Commission, the staff is preparing an advanced notice of rulemaking to announce the NRC's intention of requiring a baccalaureate degree of applicants of senior operators' licenses. The rule will also set minimum experience requirements for one SO on each shift. The staff will evaluate public comments and prepare the proposed rule and accompanying policy statement in FY 1987.

The staff is reviewing the current Policy Statement and the two Generic Letters 82-12 (June 15, 1982) and 82-16 (Spetember 20, 1982) on nuclear power plant staff working hours. Underlying the Policy Statement and the Generic Letters is the concern that excessive use of overtime, unduly long shifts, or long work assignments under particularly arduous conditions may degrade the performance of operators, maintenance, and/or surveillance personnel. The staff is reviewing the technical evidence on fatigue-related loss of human performance and is planning to draft an updated policy statement and generic letter in FY 1986.

The staff is currently revising Regulatory Guide 1.114, "Guidance to Operators at the Controls and to Senior Operators in the Control Room of a Nuclear Power Unit," and the corresponding Standard Review Plan, Section 13.1.2, "Operating Organization." The purpose of these revisions is to bring the language of these documents into conformance with the

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requirements in the Licensed Operator Staffing Rule, 10 CFR 50.54(m)(2)(iii). The revisions will not introduce new requirements beyond those of the rule.

3.5.2 Industry Activities

INPO's Job/Task Analysis program for operating and support personnel provides a data source for developing criteria for NPP personnel qualifications. An industry standards committee [American National Standards Institute/American Nuclear Society (ANS 3.1) working group] also is developing recommendations on qualifications including experience and education for an American National Standard on selection, qualifications, and training of personnel for NPPs. NUMARC has proposed shift-experience guidelines for near-term operating licenses (NTOLs) in accordance with the requirements of Generic Letter 84-16.

Industry will develop programs to ensure the adequacy of personnel qualification programs through the accreditation of training programs.

3.6 Management and Organization

As directed by the Commission's "Policy and Planning Guidance, 1986," NUREG-0885 Issue 5, the staff is moving toward performance-based rather than prescriptive regulation. As a result, developmental work as part of the Human Factors Program Plan related to new regulations involving "Management and Organization" has been deferred. In place of generic approaches directed at developing regulations the staff has been directed to focus on actual management performance and effectiveness through its program for the "Systematic Assessment of Licensee Performance."

3.7 Human Performance (Human Factors Issues Branch)

The goal of this Element is to develop and implement improved methods of experience feedback. This is to be accomplished by systematically identifying the causitive factors of particularly good or particularly poor human performance in reactor operational events. These insights will be used to sharpen the focus of the regulatory program in all its human factors dimensions to identify and establish the priorities for resolving human factors issues.

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Underlying this element is the concern that many clues to the origin of human errors or noteworthy human successes in dealing with operating events are escaping systematic evaluation in the existing experience feedback programs. In addition, the staff is concerned that it is not as well-equipped as it might be to discriminate over- from under-regulation in human factors aspects of reactor safety regulation. Better tools are needed to evaluate the importance and priorities warranted by human factors safety issues.

The benefits of pursuing this element include: (1) better practices for formal incident investigations, augmented inspections and LER reportage requirements for human performance aspects of operating events, (2) better understanding of the strengths and weaknesses of the industry's experience feedback mechanisms for human factor-related events, (3) better information on the causitive factors responsible for particularly good or particularly bad human performance in operational events, (4) more objective and better documented bases for identifying and correcting instances of over-, under-, or mistargeted regulation in all human factor aspects of reactor safety regulation, and (5) better prioritization, budgeting, and program planning in the resolution of human factors issues. In summary, the focus of the human factors regulatory program can be sharpened, made less burdensome, and more effective in assuring no undue risk to the health and safety of the public.

3.7.1 Major Tasks

Human factors experts will serve on Incident Investigation Teams established by AEOD, and DHFT will assist AEOD in developing human factors aspects of the protocol for the formal Incident Investigation Program.

The staff will study the Augmented Inspection Program, the Licensee Event Report Program, and continue to study the Incident Investigation Program to develop improved protocols for investigations, inspections, and reportage, where warranted, to assure that causitive factors of particularly good or poor human performance are recorded in a form suitable for use in evaluating the strengths and weaknesses in the human factors aspects of reactor safety regulation.

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The staff will re-examine a selected set of the more serious abnormal occurrences, review a selected set of reactor risk assessments and review research studies to better define the potential role of plant personnel in preventing, exacerbating or limiting events with the potential to produce substantial offsite radiological hazards. The study will reassess the emphasis on human factors, and reassess the priorities for the resolution of generic safety issues concerning human factors. The study will provide the foundation for regulatory analyses and compliance with the backfit rule in any future development of human factors regulations.

3.7.2 Industry and Related Activities.

The industry, through INPO, has established the SEE-IN program and, more recently, the Human Performance Evaluation System. The staff intends to assess the effectiveness of these programs as experience feedback mechanisms for industry self-improvement, will draw upon the industry know-how, where appropriate, for use in improving NRC experience feedback programs, and will offer advice, where warranted, on potential improvements to the industry programs.

The Office of Nuclear Regulatory Research is contracting with the National Academy of Sciences to conduct a study of human factors research and to develop recommendations for further research. This project will constitute a major contribution to the staff's program to reevaluate the human factors program plan.

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APPENDIX A

HUMAN FACTORS PROGRAM PLAN ACCOMPLISHMENTS

The activities and accomplishments are listed by Program Element.

1. Training

In response to Section 306 of the Nuclear Waste Policy Act of 1982, the staff developed requirements for an integrated systems approach to training, qualifications and operator licensing. This involved preparing proposed rule and regulatory guides for publication for public comment. In doing so, the staff produced SECY 84-76, SECY 84-76A and SECY 84-76B. Subsequently, in response to the NUMARC request for the Commission to delay any rulemaking to enable industry self-regulation, the staff prepared SECY 85-1, "Policy Statement on Training and Qualifications of Nu lear Power Plant Personnel." This Policy Statement was published in the Federal Register on March 20, 1985 (p. 1147). Subsequently, in support of the training improvement effort NRC and INPO prepared and signed a revised Memorandum of Agreement (MOA) on July 12, 1985. The Policy Statement endorses the INPO Accreditation Program as the means of ensuring that the five essential elements of training as described in the Policy Statement are met in industry training. These actions were part of the closeout of TMI Action Plan Items I.A.2.2, "Training and Qualifications of Operations Personnel" and I.A.2.7, "Training Accreditation."

NUREG/CR-4258, "An Approach to Team Skills Training of Nuclear Power Plant Control Room Crews," provides background information and a user-oriented description of the approach to team skills training in nuclear power plants. NUREG/CR-4258 was published as information which may be used by nuclear utility trainers, but it is not an NRC requirement. The report completes TMI Action Plan Item I.A.2.5, "Plant Drills."

NUREG/CR-4344, "Instructional Skills Evaluation in Nuclear Industry Training," has been completed. The report contains user-oriented performance

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statements of instructional skills. The report provides guidance for nuclear power plant training programs. It has been provided to INPO for their use in accreditation programs. The report completes TMI Action Plan Item I.A.2.3, "Administration of Training Programs."

"Training Review Criteria and Procedures" was prepared for staff use in the conduct of independent evaluations of nuclear utility training programs. The criteria utilized are identical to those stated in the Commission's Policy Statement. The procedures are similar to an IE inspection module and provide guidance for the staff for assessing if the Commission's Policy Statement objectives have been met. The procedures include observation check lists for evaluating training and questions related to training program design and content. NUREG/CR-3414, "Evaluation of Training Programs and Entry Level Qualifications for Nuclear Power Plant Control Room Personnel Based on the Systems Approach to Training," served as a primary source for this document.

As part of the overall training evaluation effort, the staff prepared a protocol to be used in observing INPO Accreditation Team visits. This protocol assists in achieving thorough and consistent reviews of the INPO Team visits.

NUREG/CR-3481, Vol. 1, "Nuclear Power Plant Personnel Qualifications and Training: TAPS - The Task Analysis Profiling System," provides an automated task analysis profiling system for use on a personnel computer for linking the behaviors of NPP operators in performing their tasks and the measurement tools needed to evaluate their in-plant performance. TAPS can assist in the identification of the entry-level skill, knowledge, ability, and attitude (SKAA) requirements for various tasks and rapidly associates them with measurement tests and human factors principles. The system can be used by NRC, for evaluation of training or by industry for development of training.

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NUREG/CR-3481 "Nuclear Power Plant Personnel Qualifications and Training: TAPS - The Task Analysis Profiling System," June 1985.

SECY 84-76 "Proposed Rulemaking for Operator Licensing and for Training and Qualifications of Civilian Nuclear Power Plant Personnel," February 13, 1984.

SECY 84-76A "Alternative to Proposed Rulemaking for Training and Qualifications of Civilian Nuclear Power Plant Personnel (SECY 84-76)," June 20, 1984.

SECY 84-76B "Rulemaking for Training and Qualifications of Civilian Nuclear Power Plant Personnel," September 6, 1984.

NUREG/CR-4258 "An Approach to Team Skills Training of Nuclear Power Plant Control Room Crews," 1985.

NUREG/CR-4344 "Instructional Skills in Nuclear Industry Training," 1985.

NUREG/CR-4439 "Training Review Criteria and Procedures," 1985.

NUREG/CR-3414 "Evaluation of Training Programs and Entry Level Qualifications for Nuclear Power Plant Control Room Personnel Based on the Systems Approach to Training," 1983.

SECY 85-1 "Policy Statement on Training and Qualifications of Nuclear Power Plant Personnel," December 31, 1984.

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2. Licensing Examinations

Rulemaking amending 10 CFR Part 55, "Operators' Licenses" and a conforming amendment to Part 50 was published for public comment. This rulemaking was part of the response to Section 306, PL 97-425. Proposed changes to Regulatory Guides 1.8, "Personnel Qualifications and Training," 1.134, "Medical Evaluation of Nuclear Facility Personnel Requiring Operator Licenses," and 1.149, "Nuclear Power Plant Simulators for Use in Operator Licensing Examinations" were included. This action codifies existing requirements, improves and simplifies the operator licensing process and includes the use of nuclear power plant simulators in initial and requalification examinations.

NUREG-1122, "Knowledge and Abilities Catalog for Nuclear Power Plant Operators: Pressurized Water Reactors" was completed. This NUREG identifies the knowledge and abilities required of operators to safely operate nuclear power plants. Data was obtained from the INPO Job and Task Analyses (JTA).

NUREG-1121, "Examiners' Handbook for Developing Operator Licensing Examination," was developed and is being pilot tested. It outlines the manner in which the knowledge catalogs are used to construct valid, reliable examinations.

The development of the Computerized Examination Question Bank was completed and brought on-line during FY 1984. NRC Examiners use the Question Bank to enhance their capability to prepare more valid and reliable examinations and to increase their efficiency in preparing examinations. The Question Bank can be accessed through IBM-PCs.

NUREG/CR-4188, Vol. 1, "Nuclear Power Plant Simulation Facility Evaluation Methodology: Handbook" and NUREG/CR-4188, Vol. 2, "Nuclear Power Plant Simulation Facility Evaluation Methodology: Technical Bases" provide a

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methodology for evaluating NPP simulation facilities with regard to their acceptability for use in the NRC operator licensing process.

The staff prepared SECY 84-167, "Use of the FAA Check-Pilot Approach for Reactor Operator Requalification," in 1984. IE discusses the possible adaptation of the Federal Aviation Administration's air carrier airman examiners process to the requalification of nuclear power plant operators. A possible "check-operator" program for the nuclear industry was described. The Commission has elected not to implement the concept.

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NUREG-1122, "Knowledge and Abilities Catalog for Nuclear Power Plant Operators: Pressurized Water Reactors"

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NUREG/CR-4188, Volume 2, "Nuclear Power Plant Simulation Facility Evaluation Methodology: Technical Bases"

SECY 84-167, "Use of the FAA 'Check Pilot' Approach for Reactor Operator Qualification"

49 FR-46428, Proposed rule amending 10 CFR 55, "Operators' Licenses," November 24, 1985.

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3. Procedures

In response to TMI Action Plan Item I.C.1 (Short-Term Accident Analysis and Procedures Revision) initiatives, the staff prepared NUREG-0799, "Draft Criteria for Preparation of Emergency Operating Procedures," and NUREG-0899, "Guidelines for the Preparation of Emergency Operating Procedures." These documents served as the basis for defining the staff's views for upgrading emergency operating procedures (EOPs) and currently provide the nuclear industry with guidance for upgrading EOPs.

A project which examined industry's methods for implementing revisions to EOPs was completed. The project considered: (1) methods of implementing revised EOPs in the nuclear industry and related industries, (2) the existance of professional standards for revising procedures, and (3) the possibility of "negative transfer of training" and how to reduce or eliminate it. Negative transfer of training is the detrimental effect of previously learned knowledge and experience on the learning of new information or a new task. NUREG/CR-3632, "Methods for Implementing Revisions to Emergency Operating Procedures," was published in August 1984, documenting the results of this project. It provided information of assistance to the industry in implementing revised EOPs.

In July 1985, Revisions were published to the Standard Review Plan (SRP), Section 13.5.2, "Operating and Maintenance Procedures," including an Appendix, "Review Procedures for the Evaluation of Procedure Generation Packages." This Section and Appendix of the SRP are used by the staff as review criteria and guidance in evaluating licensee and applicant programs for developing and implementing Emergency Operating Procedures.

A comparative study was completed which examined the impact on operator performance of transitioning from procedure to procedure using either event-based or function-oriented EOPs. Transitions which were studied included movements between procedure types (e.g., moving from an EOP to an

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Abnormal Operating Procedure within an event or function-based EOP) and moving within EOP procedure types (i.e., moving from one function-based EOP to another or one event-based to another). The results of this project are contained in a contractor report titled, "Application of Task Analysis of Nuclear Power Plant Control Room Crews: Procedure Interface Issues," January 1986. The results of this report are being incorporated into a larger, on going project to develop guidance for achieving successful transitions with nuclear power plant operating procedures.

A draft revision to the IE inspection module for reviewing EOPs has been completed. This revision reflects recent changes to the Standard Review Plan (Section 13.5.2) and is designed to assist inspectors in the evaluation of licensee function-oriented EOPs.

Contractor effort was completed and a final report is being submitted to the staff providing recommendations for upgrading procedures for normal and abnormal power plant operations. The findings of this report will be used to determine the need for regulatory action in upgrading other types of procedures.

Human engineering problems associated with presenting plant procedural information using different media (e.g., hardcopy, computer display) and formats (e.g., narrative, flo-charts, etc.) were investigated. "Methods for Evaluating Alternative Techniques and Formats for Presenting Procedures for Nuclear Power Plants," describes the research examining the advantages and disadvantages of various combinations of media and formats for presenting plant operating procedures.

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NUREG-0799, "Draft Criteria for Preparation of Emergency Operating Procedures," June 1981.

NUREG-0899, "Guidelines for the Preparation of Emergency Operating Procedures," August 1982.

NUREG/CR-3632, "Methods for Implementing Revisions to Emergency Operating Procedures," August 1984.

NUREG/CR-3817, Development, Use and Control of Maintenance Procedures in Nuclear Power Plants: Problems and Recommendations, January 1985.

NUREG-0800, "Standard Review Plan, Section 13.5.2, Operating and Maintenance Procedures," July 1985.

Final Report, "Application of Task Analysis of Nuclear Power Plant Control Room Crews: Procedure Interface Issues," January 1986.

Final Report, "Operating Procedures in Nuclear Power Plants: Practices and Problems," March 1986.

Final Report, "Methods for Evaluating Alternative Technique and Formats for Presenting Procedures in Nuclear Power Plants," September 1985.

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4. Man-Machine Interface

NUREG-0700, "Guidelines for Control Room Design Reviews," provides a "standard of quality" for annunciator systems which, if utilized effectively, should minimize the potential for human error associated with these systems. However, some of these standards will be difficult to apply to existing control rooms except as long-term design modifications. Also, an assessment of the impact of the NUREG-0700 guidelines on operating control rooms was needed to identify possible revisions to the guidelines. NUREG/CR-3217, "Near-Term Improvements for Nuclear Power Plant Control Room Annunciator Systems," provides this information.

Recommendations for improving nuclear power plant maintainability have been developed under contract to the staff. The process involved review of existing documents and consolidation of pertinent recommendations in NUREG/CR-3517, "Human Engineering Guidelines for Nuclear Power Plant Maintainability."

Presently 10 CFR Part 50.34(f), "Additional TMI-Related Requirements," requires each applicant for a light-water reactor construction permit or manufacturing license to provide, for NRC review, a control room design that reflects state-of-the-art human factor principles. To provide staff guidance pertinent to the interface between new control and display techniques and the human operator, the following activities were undertaken: (1) develop evaluation methods and design criteria for visual displays to be used as a Regulatory Guide; (2) establish criteria needed for regulatory assessment of advanced control room concepts; and (3) track and evaluate new and developing technologies that have potential for application in NPP control rooms such as artificial intelligence applications.

A handbook, NUREG/CR-4227, titled, "Human Engineering Guidelines for Evaluation and Assessment of Video Display Units," was published in July

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1985. This handbook provides references to known guidelines for human factors evaluation of video display units (VDUs). It is formatted as a "cookbook" of acceptance guidelines for evaluating VDUs already designed or planned for service in NPP control rooms. The areas addressed are video displays, controls, control/display integration, and workplace layout.

We expect advanced technologies to be utilized increasingly as a replacement or supplement for conventional hard-wired annunciator systems. Guidelines for annunciator improvements were developed by PNL, under contract to the NRC, based on an evaluation of results from EPRI, RES, Halden, and other advanced concept activities at Seabrook and Savannah River Laboratory. These guidelines are published in NUREG/CR-3987, "Computerized Annunciator Systems."

Preliminary research into potential applications of artificial intelligence (AI) to the NPPs was conducted and reported in three Idaho National Engineering Laboratory (INEL) reports, "Response Tree Evaluation Implications for the Use of Artificial Intelligence in Process Control Rooms," NUREG/CR-3461, "Response Tree and Expert Systems for Nuclear Reactor Operations," NUREG/CR-3631, and "Response Tree Evaluation: Experimental Assessment of an Expert System for Nuclear Reactor Operators," NUREG/CR-4272. These reports discuss the applicability of AI-like approaches as operator aids.

Revisions to the NRC Standard Review Plan, Section 18.0, "Human Factors Engineering" were completed. Section 18.1, "Control Room" with Appendix A, "Evaluation Criteria for Detailed Control Room Design Review (DCRDR)" and 18.2, "Safety Parameter Display System (SPDS)," and Appendix A, "Human Factors Review Guidelines for the Safety Parameter Display System" were published in FY 1985. These sections to the SRP are used as review criteria by the staff in the evaluations of DCRDRs and SPDSs

The preliminary investigation into the allocation of functions in nuclear power plants identified functions of operating crews and addressed some of the theoretical and methodological issues in the area of function allocation.

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The Pacific Northwest Laboratory (PNL) completed a project to identify human factors deficiencies in safety-significant control stations outside the control room of a nuclear power plant and to determine whether NUREG-0700, "Guidelines for Control Room Design Reviews," would be sufficient for reviewing those local control stations (LCSs). The project accomplished this task by first, reviewing existing data pertaining to human factors deficiencies in LCSs involved in significant safety actions; second, surveying LCSs environments and design features at several operating nuclear power plants; and third, assessing the results of that survey with respect to the guidance in NUREG-0700. As stated in the report entitled "Potential Human Factors Deficiencies in the Design of Local Control Stations and Operator Interfaces in Nuclear Power Plants," NUREG/CR-3696, the study's conclusions were: (1) a definitive list of safety-significant local control stations cannot be specified because power plant designs vary significantly; (2) most, if not all, local control stations have design deficiencies that could be corrected by applying human factors engineering principles; and (3) NUREG-0700 is generally applicable to LCSs but that guidance is needed to address the design of manually-operated valves and the design requirements of LCSs in extreme environmental conditions. Finally, the study recommended an approach for improving present LCSs to reduce the likelihood of operator errors.

The safety aspects of monitoring the operational status of safety systems in nuclear power plants were studied. The goals of the study were to assess the effectiveness of current monitoring systems and procedures, to develop acceptance criteria by which the adequacy of safety status monitoring systems can be evaluated, to develop near-term guidelines for reducing human errors associated with monitoring safety system status, and to recommend a regulatory position on this issue. A review of safety system status monitoring practices indicated that current systems and procedures do not adequately aid control room operators in monitoring safety system status. The PNL report entitled "Safety System Status Monitoring," NUREG/CR-3621, suggests acceptance criteria for meeting the functional requirements of an adequate system for monitoring safety system status. Also suggested are

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near-term guidelines that could reduce the likelihood of human errors in specific, high-priority status monitoring tasks.

An experimental and analytical research study of the effects of stress on operator decision making was completed and the results published in NUREG/CR-4040, "Operational Decisionmaking and Action Selection Under Psychological Stress in Nuclear Power Plants."

The NRC continued its participation in the multinational Halden Reactor Project at Halden, Norway. A major activity in the Man-Machine Interaction research of particular interest to NRC is the data analysis and conclusions from experiments with the NORS/ACCO and conventional annunciator systems. These experiments concerned the impact of alarm filtering on operator performance, and the results will be reported in early FY 1986.

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NUREG/CR-2118 - "Availability of Hardened Computer Systems"

NUREG/CR-2147 - "Nuclear Control Room Annunciators: Problems and Recommendations"

NUREG/CR-2587 - "Functions and Operations of Nuclear Power Plant Crews"

NUREG/CR-2623 - "The Allocation of Functions in Man-Machine Systems: A Perspective and Literature Review"

NUREG/CR-2711 - "Performance and Design Requirements for a Graphics Display Research Facility"

NUREG/CR-2776 - "Alarms within Advance Display Systems: Alternatives and Performance Measures"

NUREG/CR-2828 - "Nuclear Control Room Modifications and Role of Transfer of Training Principles: A Review of Issues and Research"

NUREG/CR-2916 - "An Empirical Examination of Evaluation Methods for Computer Generated Displays: Psychophysics"

NUREG/CR-2942 - "CRT Display Evaluation: The Multidimensional Rating of CRT-Generated Displays"

NUREG/CR-3003 - "Human Engineering Design Considerations for Cathode Ray Tube-Generated Displays, Volume II"

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NUREG/CR-3114 - "Proceedings of Workshop on Cognitive Modeling of Nuclear Plant Control Rooms, August 15-18, 1982"

NUREG/CR-3217 - "Near-Term Improvements for Nuclear Power Plant Control Room Annunciator Systems"

NUREG/CR-3331 - "A Methodology for Allocating Nuclear Power Plant Control Functions to Human or Automatic Control"

NUREG/CR-3461 - "Response Tree Evaluation Implications for the Use of Artificial Intelligence in Process Control Rooms"

NUREG/CR-3557 - "CRT Display Evaluation: Checklist of CRT Generated Displays"

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NUREG/CR-3621 - "Safety Systems Status Monitoring"

NUREG/CR-3631 - "Response Tree and Expert Systems for Nuclear Reactor Operations"

NUREG/CR-3684 - "Nuclear Power Plant Alarm Prioritization (NPPAP) Program Status Report January 1, 1983 to September 31, 1983"

NUREG/CR-3696 - "Potential Human Factors Deficiencies in the Design of Local Control Stations and Operator Interfaces in Nuclear Power Plants"

NUREG/CR-3987 - "Computerized Annunciator Systems"

NUREG/CR-4040 - "Operational Decision making and Action Selection Under Psychological Stress in Nuclear Power Plants"

NUREG/CR-4227 - "Human Engineering Guidelines for Evaluation and Assessment of Visual Display Units"

NUREG/CR-4272 - "Response Tree Evaluation: Experimental Assessment of an Expert System for Nuclear Reactor Operators"

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5. Staffing and Qualifications

A "Draft Policy Statement on Engineering Expertise on Shift" was published in the Federal Register (48 FR 33781) on July 25, 1983, for public comment. Based on these public comments, the staff prepared a final policy statement in SECY-84-355. The Commission then directed the staff to negotiate the policy statement with NUMARC. That revised final policy statement was presented to the Commission in SECY-85-150. The Commission approved the policy statement with modifications, on September 12, 1985.

The Policy Statement offers licensees options for providing engineering expertise on shift. NUREG/CR-3785, "Alternative Approaches to Providing Engineering Expertise on Shift," provided a technical evaluation which supports this action. NUREG/CR-3785, which was published in May 1984, reports on a study of the role of engineering expertise on shift in nuclear power plants. Both shift and non-shift alternatives were studied, with the on-shift engineer or the degreed shift supervisor appearing to be superior to the current STA approach.

A proposed rule (SECY 84-106) was prepared which would have required that licensees of NPPs have on each shift, a senior manager responsible for integrated management of shift operations, who holds a bachelor's degree, has five years nuclear power operating experience, and holds a senior operator's license. The Commission voted against publication of the proposed rule.

The job-related educational qualifications for licensed operators were evaluated and reported in NUREG/CR-4501, "Assessment of Job-Related Educational Qualifications for Nuclear Power Plant Operations." The extent to which college engineering courses cover job-related academic knowledge was assessed.

In February 1985, the staff prepared a draft Advanced Notice of Rulemaking, at the direction of the Commission, announcing the intent of the NRC to issue

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a rule and accompanying policy statement requiring baccalaureate degrees for future applicants for senior operator licenses and establishing both degree and experience requirements for one of the senior operators on each shift.

A study was conducted to evaluate the feasibility of licensing or certifying personnel other than licensed operators and senior licensee officials. The study had limitations associated with sample size, narrow focus, and use of dated material. However, the staff concluded that the NRC has no basis at this time for recommending any change in the licensing of personnel. This recommendation closed out TMI Action Plan Issue I.A.3.4, "Licensing of Additional Operations Personnel."

A revision to Regulatory Guide 1.8, "Personnel Qualifications and Training," was issued for public comment in January 1985. Regulatory Guide 1.8 is included in the rulemaking pertaining to 10 CFR Part 55 as noted in Section 2 above.

One of the early products of the NRC/DHFS project on Shift Scheduling and Overtime was the technical evaluation report, PNL-5391, "Shift Scheduling and Overtime: A Critical Review of the Literature." This laid the groundwork for the rest of the project, which culminated with the issuance of NUREG/CR-4248, "Recommendations for NRC Policy on Shift Scheduling and Overtime at Nuclear Power Plants." The staff is currently evaluating the contractor's report to determine which of the suggested alternatives, if any, should be recommended to the Commission.

An Operator Feedback Project was sponsored in response to TMI Action Plan Item I.A.2.6(4), which was based on Recommendation 1.4(5) of NUREG-0585, "TMI-2 Lessons Learned Task Force Final Report." That recommendation called for an annual workshop for licensed operators that would provide "an opportunity for exchange of information on operating experiences between the NRC staff and the utility shift personnel." The staff broadened the scope of the project to include a mailed survey as well as operator workshops. This allowed the NRC staff to evaluate the effectiveness of both mechanisms for

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obtaining feedback to the NRC from utility operating staffs. NUREG/CR-3739, "The Mailed Survey," describes the workshops and the feedback that resulted. NUREG/CR-4139, "The Mailed Survey," discusses the conduct of the survey and its results. A summary assessment of alternative feedback procedures and a comparison between the workshops and the survey are treated in a letter report from the PNL Project Manager to the NRC Contract Monitor, dated January 15, 1985. Both mechanisms proved to be effective in obtaining feedback from operations personnel. Action Plan Item I.A.2.6(4) was closed out with the recommendation that either of these mechanisms be used to address specific issues of interest to the Commission, rather than using them on a routine, annual basis.

NUREG/CR-4280, "The Effects of Supervisor Experience and Assistance of a Shift Technical Advisor (STA) on Crew Performance in Control Room Simulators," provides the results of an experiment on a PWR training simulator to develop a data base for evaluating the effects of selected performance shaping factors on the performance of control room operators. The factors investigated were the experience level of the Senior Reactor Operator (SRO) in the supervisor's role and the presence of an STA to assist the operation crew. Within the constraints of the experiment (i.e., operating personnel available and simulator sequences investigated), no significant differences were found in overall performance between groups led by high and low experience supervisors. The presence of the STA had no apparent effect (as defined by the performance criteria for the experiment) on overall team performance. These results were identical to a similar experiment performed with BWR crews in 1983.

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NUREG/CR-3739	"The Operator Feedback Workshop: A Technique for Obtaining Feedback from Operations Personnel," 1984.
Letter Report	"Operator Feedback Project Letter Report on Summary Assessment of Alternative Feedback Procedures and Comparison Between Workshops and Survey," 1985.
NUREG/CR-4139	"The Mailed Survey: A Technique for Obtaining Feedback from Operations Personnel," 1985.
NUREG/CR-3785	"Alternative Approaches to Providing Engineering Expertise on Shift," 1983.
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Regulatory Guide 1.8	Third Proposed Revision 2, "Qualifications and Training of of Personnel for Nuclear Power Plants," January 1985.

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6. Management and Organization

A study to develop more objective measures of nuclear utility performance was conducted. NUREG/CR-3737, "An Initial Empirical Analysis of Nuclear Power Plant Organization and Its Effect on Safety Performance" reported on the use of "safety indicators" as an evaluation tool. Based upon the results of NUREG/CR-3737, the indicators approach was developed for use in maintenance performance evaluations. This development was reported in NUREG/CR-4281, "An Empirical Analysis of Selected Nuclear Power Plant Maintenance Factors and Plant Safety." This indicators approach is currently being used in the NRC Maintenance and Surveillance Program.

A staff report on the "Review of INPO Safety Evaluation Materials" was completed. The staff concluded that the INPO evaluations were adequate.

The guidelines and workbook to be used in evaluating management and organization were published as NUREG/CR-4125, "Guidelines and Workbook for Assessment of Organization and Administration of Utilities Seeking an Operating License for Nuclear Power Plant.

Five regulatory or oversight agencies were querried to determine the methods and criteria they used in conducting management and organization audits and evaluations. The results of the review were published as NUREG/CR-3601, "Management and Organizational Assessments: A Review of Selected Organizations."

A report was prepared to assist applicants for a nuclear power plant operating license through a structured review of the organization and administration literature. The report was published as NUREG/CR-3645, "A Guide to Literature Relevant to the Organization and Administration of Nuclear Power Plants."

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A study was completed to evaluate safety review systems at nuclear power plants, and in particular the Independent Safety Engineering Group (ISEG). A review of the ISEG function was called for by Item I.B.1.2 of NUREG-0737. In general, the safety review function is an effective activity.

A report, NUREG/CR-3807, "Safety Review at Nuclear Power Plants: Recommended Guidelines," dated July 1984, was completed. The report will be used to revise Section 13.4, "Operational Review," of the Standard Review Plan when a revision is scheduled.

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7. Human Reliability

The Human Reliability Program was initiated by the Office of Research in FY 1982. When the NRC Human Factors Program Plan (NUREG-0985) was established in FY 1983 Human Reliability was included as a Program Element. In FY 1986 Human Reliability, is continuing as a Research Program.

The human reliability research program is divided into four interactive elements. The first element is directed toward identifying legitimate sources of human performance data and methods for computing error probability, performance shaping factor and uncertainty bound estimates using those data, for application in HRA segments of PRAs. This research has established an initial set of methods for acquiring the desired estimates using raw performance data from field reports, training simulator studies, computer modeling and consensus expert judgment. The NRC is currently receiving feedback on these methods based on their use in activities such as the Accident Sequence Evaluation Program (ASEP) and Risk Methods Integration and Evaluation Program (RMIEP).

The second element is directed to the development of a comprehensive data bank for processing and housing raw human performance data and probability estimates on a real-time basis, from the above sources and directly from reliability evaluations conducted by the NRC and industry. This reliability data bank has been specified in detail. Implementation of the plan for the data bank is being initiated during FY 1986.

The third element is directed toward analytic tools for employing data and probability estimates from aforementioned program elements, to quantify and interpret human performance in risk-related situations at commercial nuclear power plants. This element is also directed to improve procedures for fully integrating HRA into the PRA process.

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Such improvements in the treatment of human reliability in PRAs are needed to achieve more realistic assessments of the human's contribution to overall plant risk, and to acquire more complete qualitative and quantitative inferences about human performance aspects of Unresolved Safety Issues (USIs) and Generic Safety Issues (GSIs). To date, work on this element has produced several analytic tools for quantifying and interpreting human performance taking into account both independent and dependent behavior. The NRC is currently receiving feedback from pilot study applications of these tools from ongoing activities such as ASEP and RMIEP. Research is ongoing on improved methods to account for cognitive processing and decision making aspects of performance and on procedures for more fully integrating HRA into the PRA process.

The fourth element is directed to develop methods for utilizing quantitative and qualitative results of reliability evaluations to support resolution of USIs and GSIs (e.g., severe accident management), and to identify immediate and future human reliability research needs. Research is ongoing to achieve both of these program element objectives.

During the past four years, 32 NUREG/CR reports have been published to communicate human reliability research findings and products to NRC user groups and the general public. The following paragraphs enumerate human reliability research products developed to date under each program subelement, and their associated NUREG/CR reports. The NUREG/CR report number or numbers underlined indicate final products or description thereof. The full titles can be found in the attached bibliography.

Human Performanced Data Acquisition

- Method for estimating human error probabilities, performance shaping factors and uncertainty bounds using consensus expert judgment (NUREG/CRs 2255, 2743, 3688, 2986, 3518, 4016).

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° Computer model for simulating performance of maintenance personnel to acquire error probability, performance shaping and uncertainty bound estimates (NUREG/CRs 2668, 2669, 2670, 3274, 3275, 3626, 3634, 4104).

° Method for acquiring error probability, performance shaping and uncertainty bound estimates using training simulator data (NUREG/CR-3309).

° Method for acquiring error probability, performance shaping and uncertainty bound estimates using field reports (NUREG/CRs 1880, 2416, 2417, 2987, 3519, 4132, 4133).

Human Reliability Data Bank for collating, storing and retrieving human performance data from the above sources, and from reliability evaluations conducted by the NRC and industry (NUREG/CRs 2744, 4009, 4010).

Analytic Tools

Model for conducting micro analyses of human performance sequences (NUREG/CRs 1278, 2254).

Model for conducting macro analyses of human performance sequences (NUREG/CR 3010).

Model for calculating dependency (conditional probabilities) between steps in human performance sequences (NUREG/CRs 2211, 3837).

HRA/PRA Results Application

° Analysis of USI/GSI information/data requirements and degree to which current HRA/PRA results respond to those requirements (NUREG/CR 4103).

During the past four years, human reliability research has focused primarily on data acquisition methods, data bank specification development and tools for conducting engineering oriented analysis of human behavior. During FY 1985, and thereafter, human reliability research is shifting its focus to analytic tools for quantifying cognitive aspects of human behavior,

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procedures for integrating HRA more fully into the PRA process, methods for systematically using HRA/PRA results to support resolution of USIs and GSIs, and for obtaining more stable error probability estimates using tools that have emerged from the research program to date.

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APPENDIX B

STATUS OF TMI ACTION PLAN ITEMS

CONCERNING HUMAN FACTORS ISSUES

ITEM	TITLE	PRIMARY REFERENCE	STATUS
I.A.1.1	Shift Technical Advisor	NUREG-0737	Complete
I.A.1.2	Shift Supervisor Administrative Duties	NUREG-0660	Complete
I.A.1.3	Shift Manning	NUREG-0737	Complete
I.A.1.4	Long-Term Upgrade of Operating Personnel and Staffing	10 CFR	Complete
I.A.2.1	Immediate Upgrading of Reactor Operator and Senior Reactor Operator Training and Qualifications	NUREG-0737	Complete
I.A.2.2	Training and Qualifications of Operational Personnel	Policy Statement	Complete
I.A.2.3	Administration of Training Programs	Policy Statement	Complete
I.A.2.5	Plant Drills	NUREG/CR-4258	Complete
I.A.2.6(4)	Operator Workshops	NUREG/CR-3149	Complete
I.A.2.6	Long-Term Upgrading of Training and Qualifications		Ongoing
I.A.2.7	Accreditation of Training Institutions	Policy Statement	Complete
I.A.3.1	Revise Scope and Criteria for Licensing Examinations	NUREG-0737	Complete
I.A.3.2	Operator Licensing Program Changes	NUREG-1021	Complete
I.A.3.3	Requirements for Operator Fitness	Policy Statement	Complete
I.A.4.1	Initial Simulator Improvement	NUREG-0660	Complete
I.A.4.2	Long-Term Training Simulator Upgrade	R.G. 1.149	Complete

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ITEM	TITLE	PRIMARY REFERENCE	STATUS
I.B.1.1	Organization and Management Long-Term Improvements		Ongoing
I.B.1.2	Independent Safety Engineering Group	NUREG-0737	Complete
I.C.1	Guidance for the Evaluation and Development of Procedures for Transients and Accidents	NUREG-0737	Complete
I.C.2	Shift and Relief Turnover Procedures	NUREG-0660	Complete
I.C.3	Shift Supervisor Responsibilities	NUREG-0660	Complete
I.C.4	Control Room Access	NUREG-0660	Complete
I.C.5	Procedures for Feedback of Operating Experience to Plant Staff	NUREG-0737	Complete
I.C.6	Guidance on Procedures for Verifying Correct Performance of Operating Activities	NUREG-0737	Complete
I.C.7	NSSS Vendor Review of Procedures	NUREG-0660	Complete
I.C.8	Pilot Monitoring of Selected Emergency Procedures for NTOL Applicants	NUREG-0660	Complete
I.C.9	Long-Term Program Plan for Upgrading of Procedures		Ongoing
I.D.1	Control Room Design Reviews	Supplement 1 NUREG-0737	In Process
I.D.2	Plant Safety Parameter Display Console	Supplement 1 NUREG-0737	In Process
I.D.3	Safety System Status Monitoring		Ongoing
I.D.4	Control Room Design Standard		Ongoing
I.D.5	Improved Control Room Instrumentation Research		Ongoing
II.B.4	Training for Mitigating Core Damage	NUREG-0737	Complete

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APPENDIX C

MAJOR MILESTONES OF THE HUMAN FACTORS PROGRAM PLAN

1. Staffing and Qualifications

° Report to the Commission on the industry implementation of the policy on engineering expertise on shift.	July 1986
° Provide the Commission with proposed rulemaking package on degree and experience requirements for senior operators	April 1987
° Provide the Commission with final rulemaking package on degree and experience requirements for senior operators	December 1987
° Revision of Generic Letter 82-12 "Nuclear Power Plant Staff Working Hours".	FY 1987

2. Training

° Interim report to the Commission on the INPO-managed Training Accreditation Program.	March 1986
° Report to the Commission evaluating the effectiveness of the INPO-managed Accreditation Program, assessing the need for further rule or policy development.	FY 1987

3. Licensing Examinations

° Provide the Commission with final rulemaking package containing:	May 1986

- 10 CFR 55, "Operators Licenses";
- Reg. Guide 1.8, "Qualifications and Training of Personnel for Nuclear Power Plants";

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- Reg. Guide 1.149, "Nuclear Power Plant Simulator Facilities for Use in Operator License Examinations";

- Reg. Guide 1.134, "Medical Evaluation of Nuclear Facility Personnel Requiring Operator Licenses".

4. Procedures

No major milestones scheduled.

5. Man-Machine Interface

No major milestones scheduled.

6. Management and Organization

No major milestones scheduled.

7. Human Performance

No major milestones scheduled.

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12. SUPPLEMENTARY NOTES

13. ABSTRACT (200 words or less)

This document is the Second Annual Revision to the NRC Human Factors Program Plan. The first edition was published in August 1983. Revision 1 was published in July of 1984.

The purpose of the NRC Human Factors Program is to ensure that proper consideration is given to human factors in the design and operation of nuclear power plants. This document describes the plans of the Office of Nuclear Reactor Regulation to address high priority human factors concerns of importance to reactor safety in FY 1986 and FY 1987. Revision 2 of the plan incorporates recent Commission decisions and policies bearing on the human factors aspects of reactor safety regulation. With a few exceptions, the principal changes from prior editions refect a shift from developing new requirements to staff evaluation of industry progress in resolving human factors issues.

The plan addresses seven major program elements: (1) Training, (2) Licensing Examinations, (3) Procedures, (4) Man-Machine Interface, (5) Staffing and Qualifications, (6) Management and Organization, and (7) Human Performance.

14. DOCUMENT ANALYSIS - a. KEYWORDS/DESCRIPTORS

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